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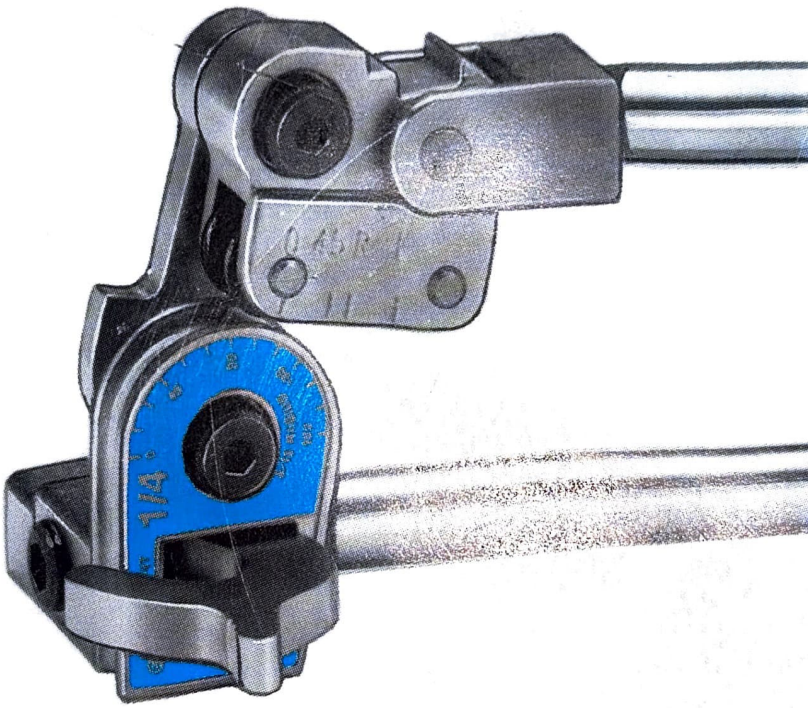
Swagelok®

Hand Tube Bender Manual



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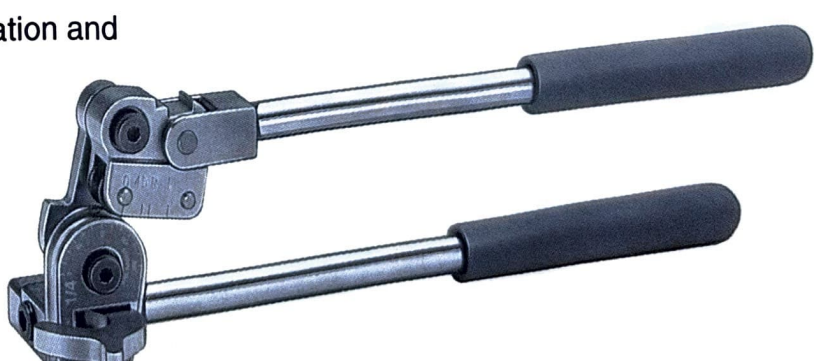
Swagelok®

Swagelok Tube Bender

The Swagelok tube benders provide consistent, high quality bends in tubing made of stainless steel, copper, steel, aluminum, and a variety of other materials.

This handbook will assist you in tube preparation and proper use of the bender.

We recommend reading this handbook in its entirety BEFORE using the bender.



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Bender Components

Tube Preparation

It is important to use high quality, annealed tubing and quality cutting tools. Proper deburring of both the inside diameter (ID) and outside diameter (OD) is required to remove all metal chips and burrs.

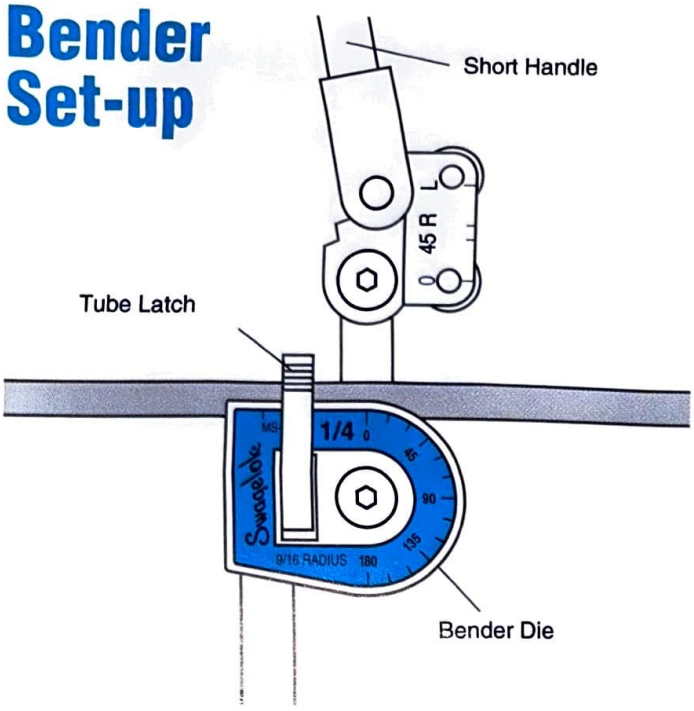
Prior to making bends, it is necessary to mark the tubing. First make a reference mark on the end of the tubing to indicate where layout measurements begin. Next, make a measurement mark to indicate where the tube bend begins. Always make this mark a full 360° around the tubing.

Tube Deburring Tool

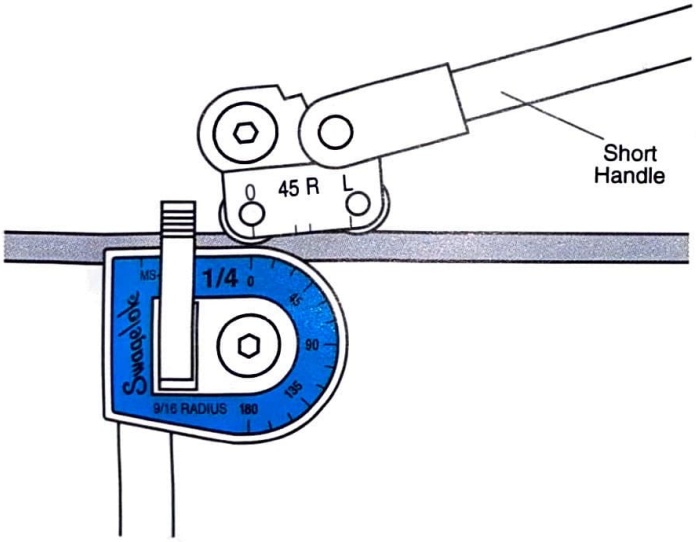
Tube Cutter

Tube Sawing Guide

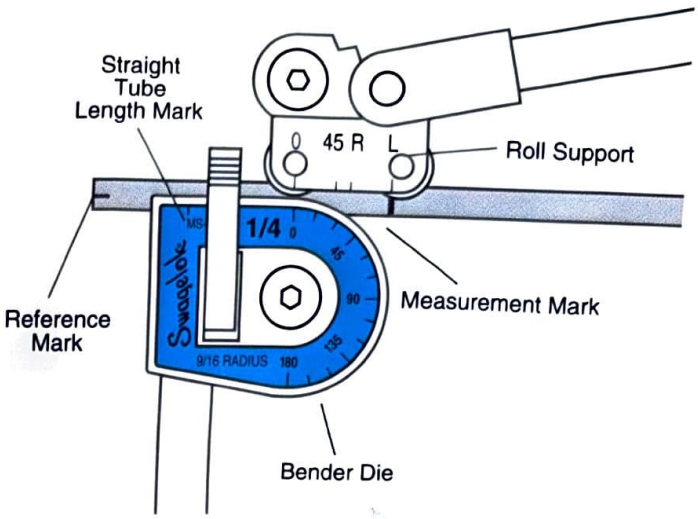
Bender Set-up



Swing the short handle up so it is above the bender die. Lower the tube latch. Place the tubing in the bender groove, and press the tube latch forward just enough to hold the tubing. This will prevent movement of the tubing during its initial positioning, yet still allow for additional tubing alignment.

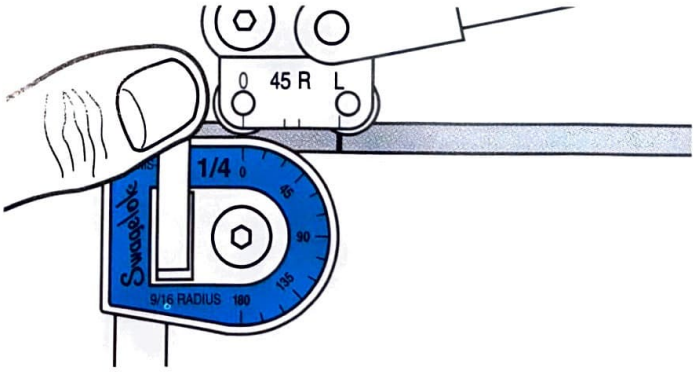


Carefully lower the short handle until the roll dies rest gently on the tubing. Keep the link straight and parallel to the long handle to prevent premature bending.



Next, align the zero on the roll support with the zero on the bender die. Then, align the measurement mark under one of the markings on the roll support. Here are some simple guidelines: If you are making a 45° bend, always align the measurement mark under the "45" on the roll support. For all other bends, measurement mark alignment will depend on the position of the reference mark. That is, if the reference mark is to the left of the measurement mark on the tubing, align the measurement mark under the "L" on the roll support. If the reference mark is to the right of the measurement mark, align the measurement mark under the "R" on the roll support.

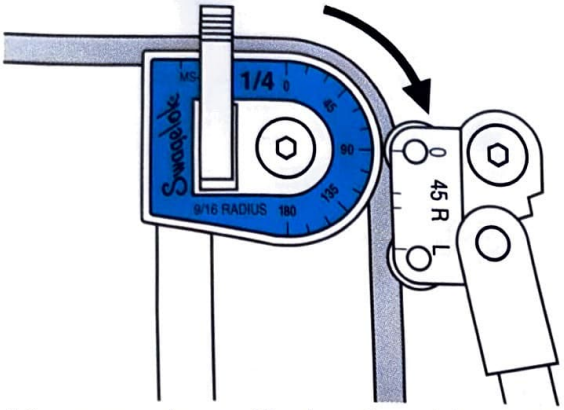
When installing fittings near tube bends, leave a sufficient length of straight tubing to allow tubing to bottom in the Swagelok tube fitting. The straight tube length mark indicates the length of tubing required from the end of the tubing to the beginning of the bend.



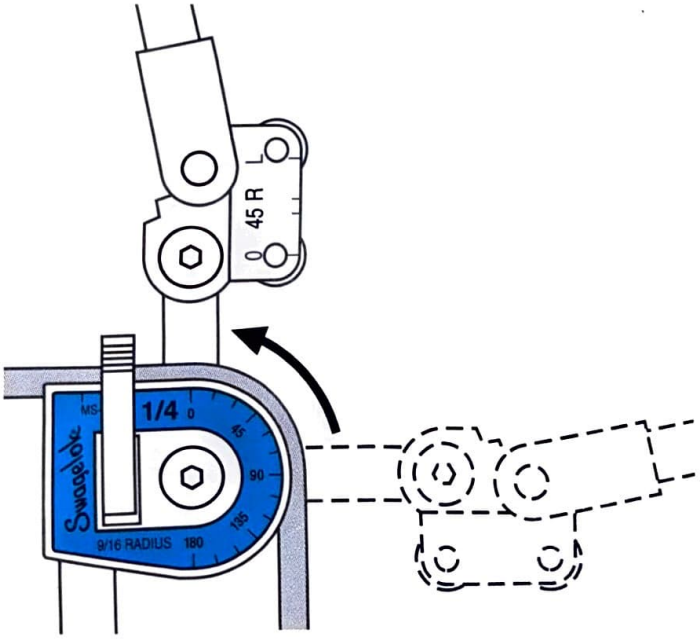
Push the tube latch firmly over the tubing to secure the tubing in the bender die.

Making Bends

Bends 90° or Less



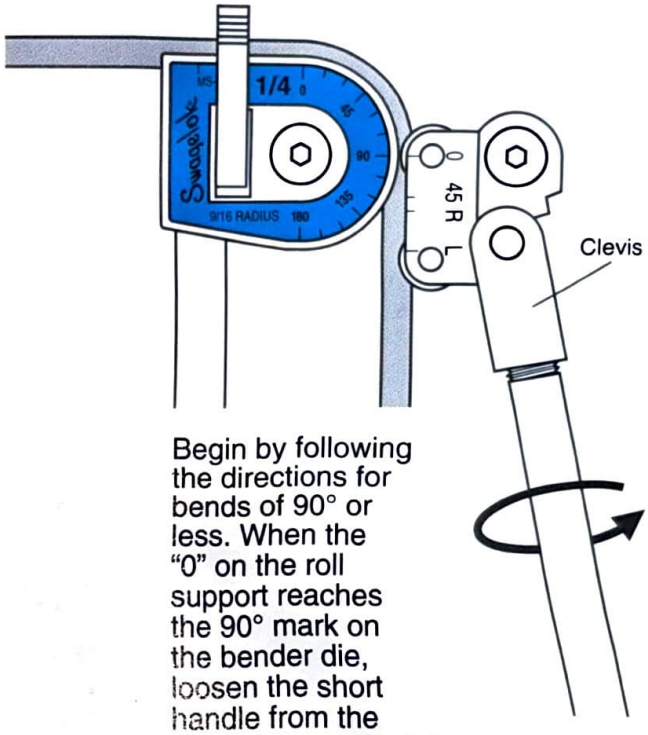
After properly positioning the tubing in the bender, slowly push the short handle down until the "0" on the roll support reaches the desired degree mark on the bender die.



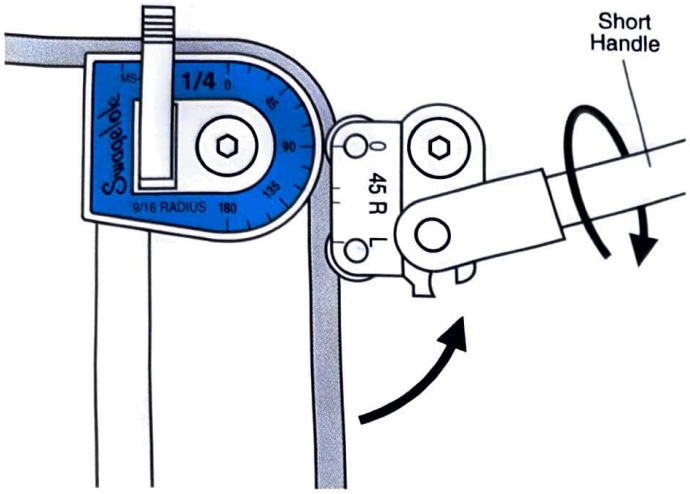
After completing the bend, swing the short handle up and away from the bender die. Unlatch the tubing and carefully remove it from the bender groove. Avoid scratching or marring the tubing during removal, since this could adversely affect sealing surfaces.

Bends Greater than 90°

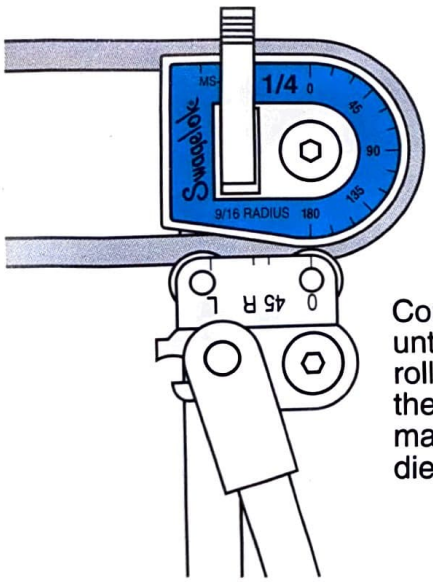
The right angle design of the Swagelok tube bender offers maximum leverage when making bends. The bender's unique design lets you continue using right angle leverage for bends greater than 90°.



Begin by following the directions for bends of 90° or less. When the "0" on the roll support reaches the 90° mark on the bender die, loosen the short handle from the clevis (approximately four turns).

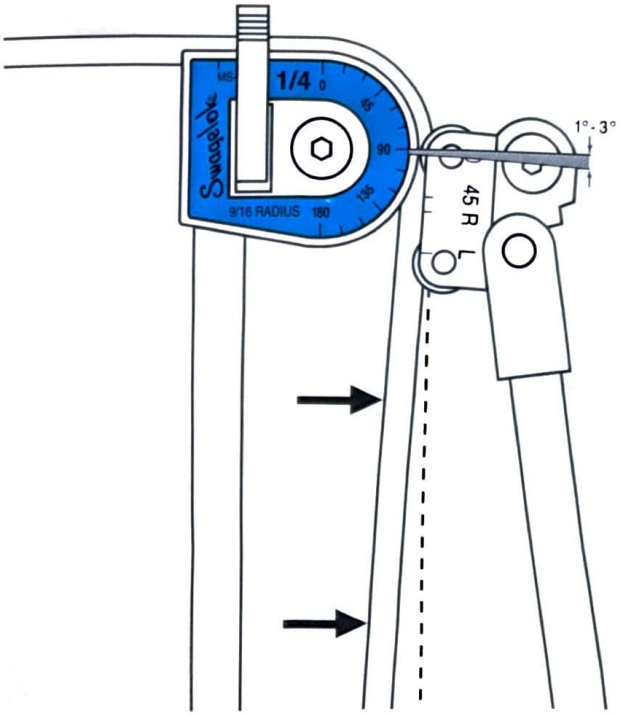


Then swing the short handle up counter-clockwise until it is slightly above the perpendicular position in relation to the long handle. Retighten the short handle. Now you will have continual right angle leverage for the rest of the bend.



Continue the bend until the "0" on the roll support reaches the desired degree mark on the bender die.

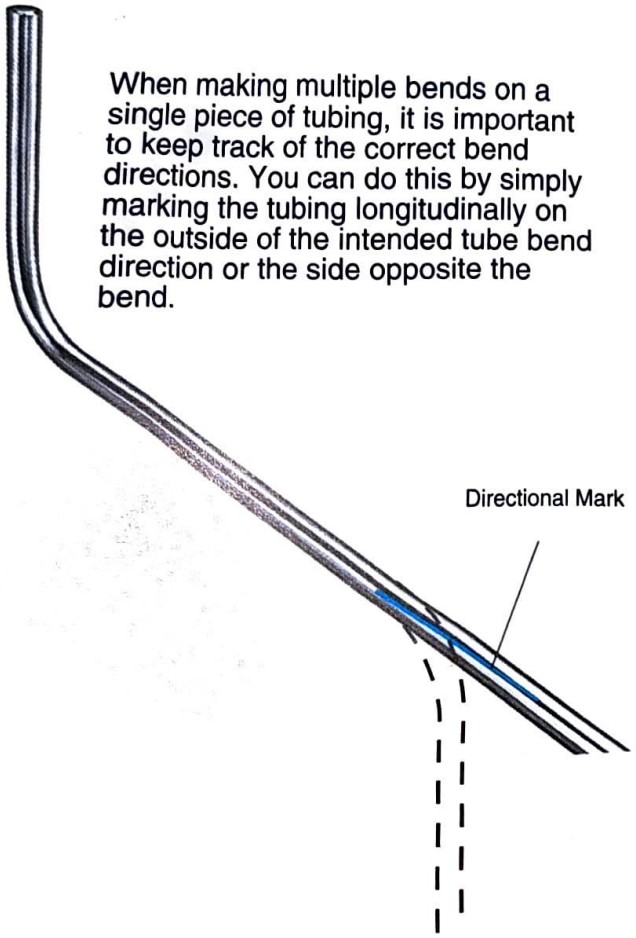
Springback

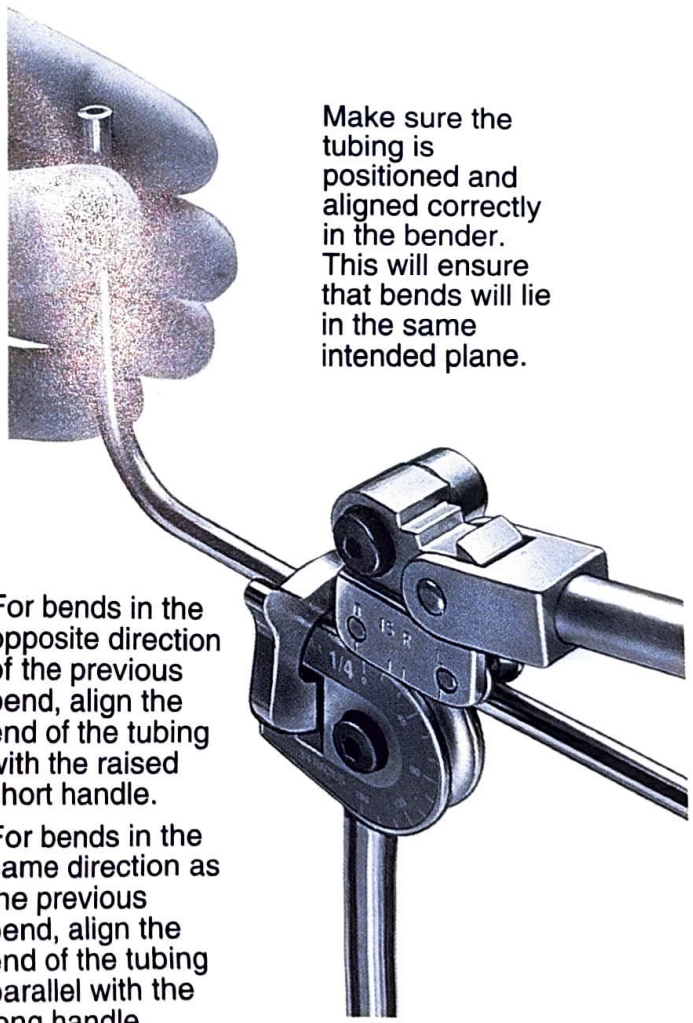


All tubing will exhibit springback after a bend is completed. Softer tubing, such as copper, will have less springback than harder tubing, such as stainless steel. Experience will help you to predict the amount of springback. Expect to allow 1° to 3° compensation depending on tubing material and hardness.

Determining Changes in Plane and Direction

When making multiple bends on a single piece of tubing, it is important to keep track of the correct bend directions. You can do this by simply marking the tubing longitudinally on the outside of the intended tube bend direction or the side opposite the bend.



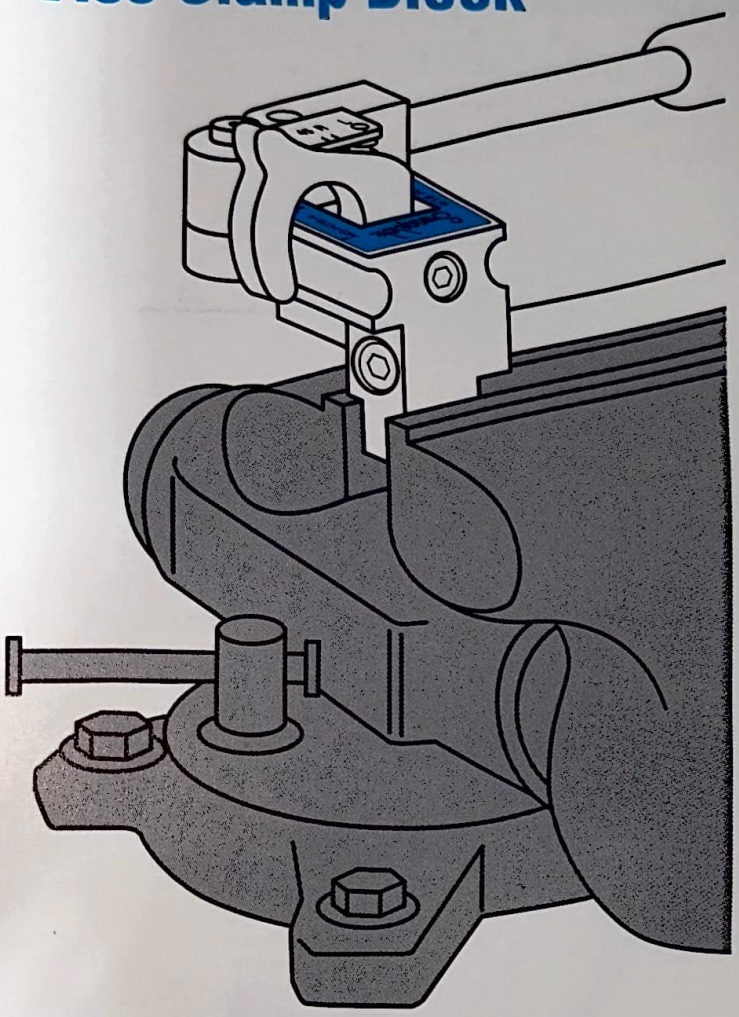


Make sure the tubing is positioned and aligned correctly in the bender. This will ensure that bends will lie in the same intended plane.

For bends in the opposite direction of the previous bend, align the end of the tubing with the raised short handle.

For bends in the same direction as the previous bend, align the end of the tubing parallel with the long handle.

Vise Clamp Block

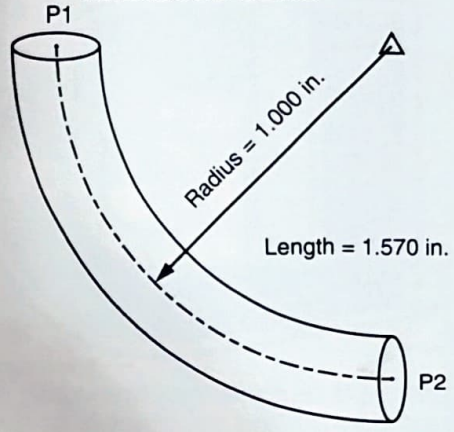


The Swagelok tube bender features a vise clamp block which allows you to clamp the bender in a vise. This feature is especially helpful when bending tubing of a hard material or of a heavy wall thickness.

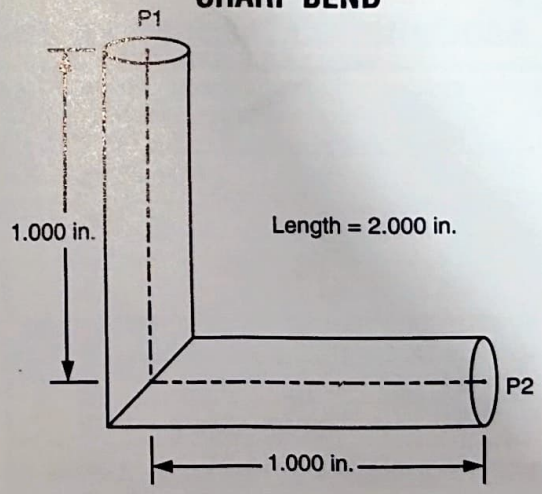
Adjustment (Gain) Calculations

When determining tube bend locations, adjustment factors must be considered to achieve proper layout.

RADIUSED BEND



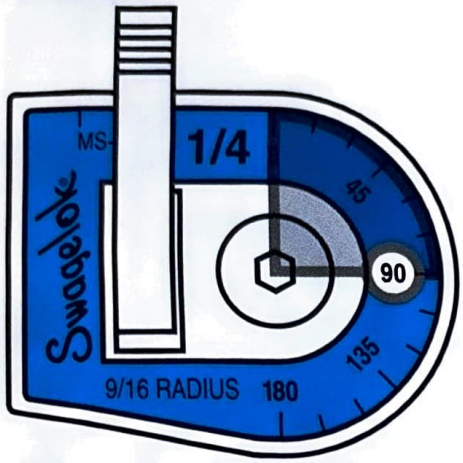
SHARP BEND



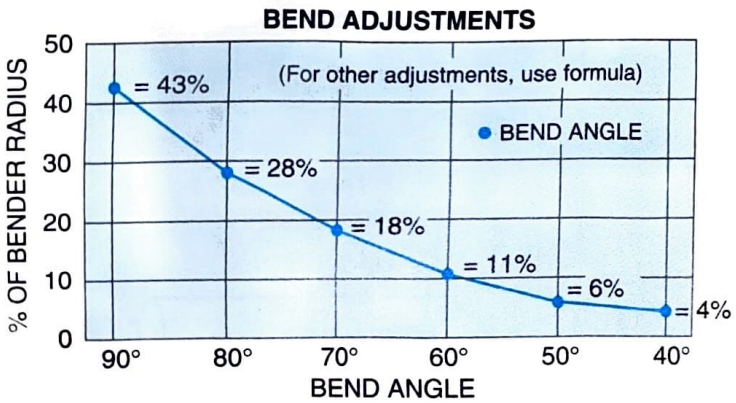
Adjustment (gain) is the difference in the length of tubing used in a radiused bend compared to the length of tubing required in a sharp bend, when measured from P1 to P2. See Figure above.

The distance around a radiused bend is always less than a sharp bend.

Adjustment (Gain) Calculations *Continued*



The adjustment factor is determined by the radius of the tube bender and the number of degrees of the bend.



ADJUSTMENT FORMULA = (2 TAN 1/2 Θ - 0.01745 Θ) × R

TAN = Tangent Θ = Bend Angle R = Radius

Fractional Adjustment Calculations

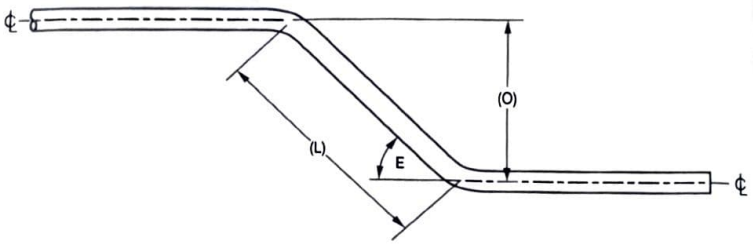
Tube OD (in.)		1/2	3/8	5/16	1/4	1/4
Bend Radius		1 1/2	15/16	15/16	9/16	3/4
Bend Aangle	90°	5/8	13/32	13/32	1/4	5/16
	85°	1/2	11/32	11/32	3/16	1/4
	80°	7/16	9/32	9/32	5/32	7/32
	75°	11/32	7/32	7/32	1/8	3/16
	70°	9/32	11/64	11/64	3/32	1/8
	65°	7/32	1/8	1/8	5/64	3/32
	60°	5/32	3/32	3/32	1/16	5/64
	55°	1/8	5/64	5/6	3/6	1/16
	50°	3/32	1/16	1/16	1/32	3/64
	45°	1/16	1/32	1/32	1/32	1/32

Metric Adjustment Calculations

Tube OD (mm)		12	10	8	6
Bend Radius		38	24	24	15
Bend Angle	90°	16.5	10.5	10.5	6.5
	85°	13.5	8.5	8.5	5.0
	80°	11.0	7.0	7.0	4.0
	75°	8.5	5.5	5.5	3.5
	70°	7.0	4.5	4.5	2.5
	65°	5.5	3.5	3.5	2.0
	60°	4.0	2.5	2.5	1.5
	55°	3.0	2.0	2.0	1.0
	50°	2.5	1.5	1.5	1.0
	45°	1.5	1.0	1.0	0.50

Adjustments on angles of less than 45° are minimal.

Offset Bend Formula



When offset exists, determine the length of offset (L) before calculating for the adjustment from the tube bend. To determine the length of offset, select the offset angle (E). Then, simply multiply the offset dimension (O) by the offset bend allowance.

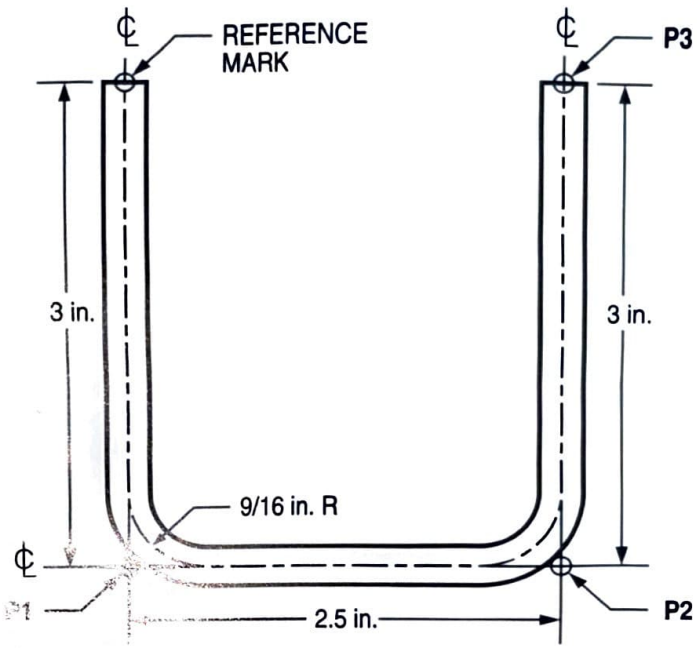
Angle E	Offset Bend Allowance				
22 1/2°	2.613	×	Offset (O)	=	Length of Offset (L)
30°	2.00	×	_____	=	_____
45°	1.414	×	_____	=	_____
60°	1.154	×	_____	=	_____

An offset bend calculation chart has been provided in 30°, 45°, and 60° offset angles. For offset dimensions (O) greater than 4 in., use the Offset Bend Formula to determine the length of the offset (L).

Offset Bend Calculations (in.)

30° Offset		45° Offset		60° Offset	
(O) dim.	(L) dim.	(O) dim.	(L) dim.	(O) dim.	(L) dim.
1	2	1	1 7/16	1	1 3/16
1 1/4	2 1/2	1 1/4	1 3/4	1 1/4	1 7/16
1 1/2	3	1 1/2	2 1/8	1 1/2	1 3/4
1 3/4	3 1/2	1 3/4	2 1/2	1 3/4	2
2	4	2	2 3/4	2	2 5/16
2 1/4	4 1/2	2 1/4	3 3/16	2 1/4	2 9/16
2 1/2	5	2 1/2	3 9/16	2 1/2	2 7/8
2 3/4	5 1/2	2 3/4	3 7/8	2 3/4	3 3/16
3	6	3	4 1/4	3	3 1/2
3 1/4	6 1/2	3 1/4	4 5/8	3 1/4	3 3/4
3 1/2	7	3 1/2	5	3 1/2	4
3 3/4	7 1/2	3 3/4	5 5/16	3 3/4	4 5/16
4	8	4	5 9/16	4	4 5/8

Accurate Bends Require Preparation



To achieve configurations mark tubing as follows:

P1 = 3 in.
P2 = P1 + 2.5 in. – ¼ in. Adjustment = 5.25 in.
P3 = P2 + 3 in. – ¼ in. Adjustment = 8 in.

90° Adjustment = ¼ in.
45° Adjustment = 1/32 in.

Practice Exercise on Measuring Tubing

For a successful layout, planning is necessary. Whenever possible, premeasure and mark the tubing prior to bending.

This exercise will illustrate measuring procedures and calculations to determine accurate lengths prior to bending. The template for this exercise is referenced as Fig. 1 on the following page. Use adjustment calculations and the Offset Bend Formula pages to assist in achieving these measurements.

1. Begin with ¼ in. OD tubing that is approximately 14 in. in length.
2. Reference the Adjustment Tables for 90° bends. Remember to mark the tubing to keep track of correct bend directions.
3. First measurement: **P1 = 2 in.** from the end of the tubing where the reference mark was made. Since no bends precede the first mark, no adjustments are necessary.
4. Second measurement: P2 = 4 in. minus the adjustment from the previous 90° bend.
   P2 = P1 + 4 in. - adjustment = _____
5. Third measurement: P3 = 2⅛ in. required offset. To determine (L), the offset bend length, reference the Offset Bend Formula Table for a 45° angle.
   L = 1.414 × 2⅛ in. =_____
   After calculating the offset length, determine the offset from the previous 45° bend.
   P3 = P2 + L - adjustment from previous 45° bend = _____
6. Fourth measurement: **P4 = P3 + 4 in. - adjustment from previous 45° bend = _____**

Note: Tube bending measurements will vary depending on the type of bender used, the accuracy of the marks on the tubing, and other factors. All premeasurements should be considered approximate. Final tube bends should be compared with a template whenever possible.

Mark Tubing as Follows:
P1 = 2 in.
P2 = P1 + 4 in. – ¼ in. =
P3 = P2 + 3 in. (Offset × Angle Factor) – 1/32 in. =
P4 = P3 + 4 in. – 1/32 in. =

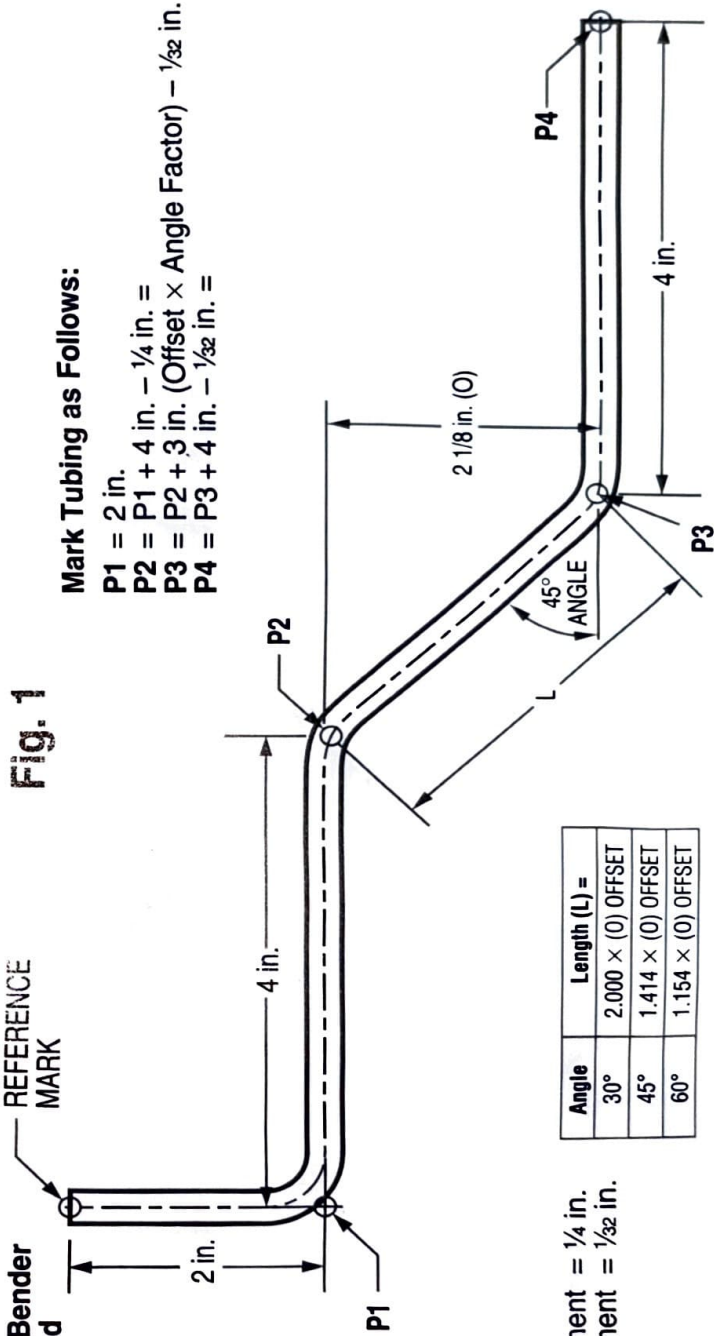


Fig. 1

Angle	Length (L) =
30°	2.000 × (O) OFFSET
45°	1.414 × (O) OFFSET
60°	1.154 × (O) OFFSET

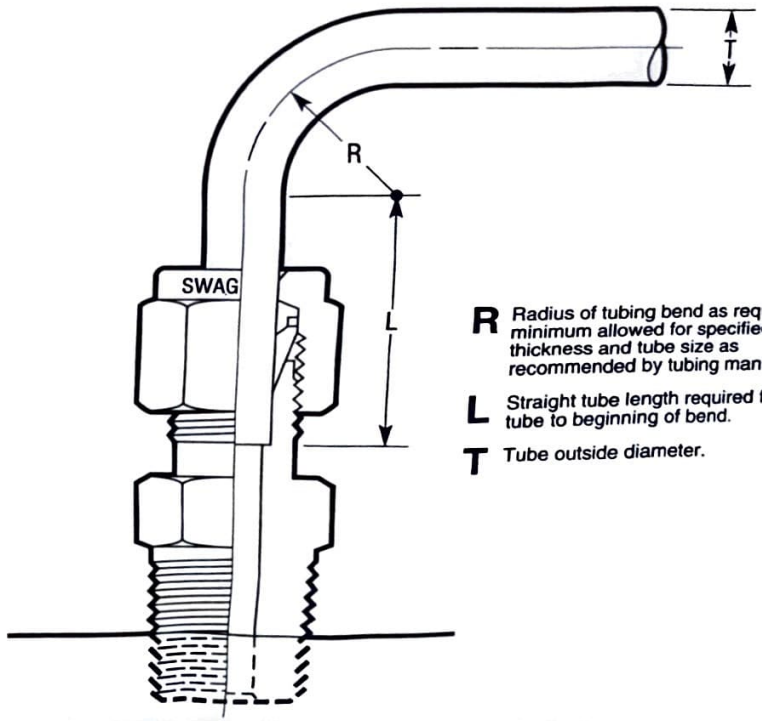
90° Adjustment = ¼ in.
45° Adjustment = 1/32 in.

1/4 in. Tube Bender (9/16 in. Bend Radius)

Tubing Installation

Properly selected tubing combined with the quality of Swagelok tube fittings, can give you leak-free systems.

When installing fittings near tube bends, there must be a sufficient length of straight tubing to allow the tube to be bottomed in the Swagelok tube fitting:



R Radius of tubing bend as required or minimum allowed for specified wall thickness and tube size as recommended by tubing manufacturer.

L Straight tube length required from end of tube to beginning of bend.

T Tube outside diameter.

T Tube OD (in.)	1/16	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	2
L Length of Straight Tube	1/2	23/32	3/4	13/16	7/8	15/16	1 3/16	1 1/4	1 1/4	1 5/16	1 1/2	2	2 13/32	3 1/4
T Tube OD (mm)	3	6	8	10	12	14	15	16	18	20	22	25	28	30	32	38
L Length of Straight Tube	19	21	23	25	31	32	32	32	32	34	34	40	53	52	54	63
R	Radius of tube bend as recommended by tubing manufacturer.															

For maximum assurance of reliable performance, use Swagelok tube fittings assembled in accordance with catalog instructions, and use properly selected and handled high quality tubing.

Decimal Equivalents

1/64 in.	= 0.01563	33/64 in.	= 0.51563
1/32 in.	= 0.03125	17/32 in.	= 0.53125
3/64 in.	= 0.04688	35/64 in.	= 0.54688
1/16 in.	= 0.0625	9/16 in.	= 0.5625
5/64 in.	= 0.07813	37/64 in.	= 0.57813
3/32 in.	= 0.09375	19/32 in.	= 0.59375
7/64 in.	= 0.10938	39/64 in.	= 0.60938
1/8 in.	= 0.125	5/8 in.	= 0.625
9/64 in.	= 0.14063	41/64 in.	= 0.64063
5/32 in.	= 0.15625	21/32 in.	= 0.65625
11/64 in.	= 0.17188	43/64 in.	= 0.67188
3/16 in.	= 0.1875	11/16 in.	= 0.6875
13/64 in.	= 0.20313	45/64 in.	= 0.70313
7/32 in.	= 0.21875	23/32 in.	= 0.71875
15/64 in.	= 0.23438	47/64 in.	= 0.73438
1/4 in.	= 0.250	3/4 in.	= 0.750
17/64 in.	= 0.26563	49/64 in.	= 0.76563
9/32 in.	= 0.28125	25/32 in.	= 0.78125
19/64 in.	= 0.29688	51/64 in.	= 0.79688
5/16 in.	= 0.3125	13/16 in.	= 0.8125
21/64 in.	= 0.32813	53/64 in.	= 0.82813
11/32 in.	= 0.34375	27/32 in.	= 0.84375
23/64 in.	= 0.35938	55/64 in.	= 0.85938
3/8 in.	= 0.375	7/8 in.	= 0.875
25/64 in.	= 0.39063	57/64 in.	= 0.89063
13/32 in.	= 0.40625	29/32 in.	= 0.90625
27/64 in.	= 0.42188	59/64 in.	= 0.92188
7/16 in.	= 0.4375	15/16 in.	= 0.9375
29/64 in.	= 0.45313	61/64 in.	= 0.95313
15/32 in.	= 0.46875	31/32 in.	= 0.96875
31/64 in.	= 0.48438	63/64 in.	= 0.98438
1/2 in.	= 0.500	1in.	= 1.00000

Inches to Metric

1/16 in.	= 1.59 mm	11/16 in.	= 17.46 mm
1/8 in.	= 3.18 mm	3/4 in.	= 19.05 mm
3/16 in.	= 4.76 mm	13/16 in.	= 20.64 mm
1/4 in.	= 6.35 mm	7/8 in.	= 22.23 mm
5/16 in.	= 7.94 mm	15/16 in.	= 23.81 mm
3/8 in.	= 9.53 mm	1 in.	= 25.40 mm
7/16 in.	= 11.11 mm	1 1/4 in.	= 31.75 mm
1/2 in.	= 12.70 mm	1 1/2 in.	= 38.10 mm
9/16 in.	= 14.29 mm	2 in.	= 50.80 mm
5/8 in.	= 15.88 mm		

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